Tutorial sheet No-4
Heat engine and entropy

1. A steel bottle V = 0.1 m^3 contains R-134a at 20°C, 200 kPa. It is placed in a deep freezer where it is cooled to -20°C. The deep freezer sits in a room with ambient temperature of 20°C and has an inside temperature of -20°C. Find the amount of energy the freezer must remove from the R-134a and the extra amount of work input to the freezer to do the process. (7.24) Ans: q12=-62.334Kj, W=9.85k

2. A car engine operates with a thermal efficiency of 35%. Assume the air conditioner has a coefficient of performance that is one third of the theoretical maximum and it is mechanically pulled by the engine. How much fuel energy should you spend extra to remove 1 kJ at 15°C when the ambient is at 35°C? (7.14) Ans: .595kJ

3. Refrigerant-12 at 95°C, x = 0.1 flowing at 2 kg/s is brought to saturated vapor in a constant-pressure heat exchanger. The energy is supplied by a heat pump with a low temperature of 10°C. Find the required power input to the heat pump. (7.41) Ans: 29.8kW

4. One kilogram of ammonia in a piston/cylinder at 50°C, 1000 kPa is expanded in a reversible isobaric process to 140°C. Find the work and heat transfer for this process. (8.10) Ans: 50.5 and 225.9 kJ

5. One kilogram of water at 300°C expands against a piston in a cylinder until it reaches ambient pressure, 100 kPa, at which point the water has a quality of 90%. It may be assumed that the expansion is reversible and adiabatic. What was the initial pressure in the cylinder and how much work is done by the water? (8.15) Ans: 2.048Mpa, 474.3kJ

6. A cylinder containing R-134a at 10°C, 150 kPa, has an initial volume of 20 L. A piston compresses the R-134a in a reversible, isothermal process until it reaches the saturated vapor state. Calculate the required work and heat transfer to accomplish this process. (8.20) Ans: **-3.83 kJ, -3.197 kJ**

7. A mass and atmosphere loaded piston/cylinder contains 2 kg of water at 5 MPa, 100°C. Heat is added from a reservoir at 700°C to the water until it reaches 700°C. Find the work, heat transfer, and total entropy production for the system and surroundings. (8.29) Ans: **874.6 kJ, 5.27kJ/K**

8. Water in a piston/cylinder is at 1 MPa, 500°C. There are two stops, a lower one at which V_{min} = 1 m^3 and an upper one at V_{max} = 3 m^3. The piston is loaded with a mass and outside atmosphere such that it floats when the pressure is 500 kPa. This setup is now cooled to 100°C by rejecting heat to the surroundings at 20°C. Find the total entropy generated in the process. (8.33) Ans: 26.27kJ/K

9. A cylinder with a linear spring-loaded piston contains carbon dioxide gas at 2 MPa with a volume of 50 L. The device is of aluminum and has a mass of 4 kg.

Everything (Al and gas) is initially at 200°C. By heat transfer the whole system cools to the ambient temperature of 25°C, at which point the gas pressure is 1.5 MPa. Find the total entropy generation for the process. (8.74) Ans: 0.552kJ/k

10. An insulated cylinder with a frictionless piston, shown in Fig. P8.76, contains water at ambient pressure, 100 kPa, a quality of 0.8 and the volume is 8 L. A force is now applied, slowly compressing the water until it reaches a set of stops, at which point the cylinder volume is 1 L. The insulation is then removed from the cylinder walls, and the water cools to ambient temperature, 20°C. Calculate the work and the heat transfer for the overall process. (8.76) Ans: **-1.90 kJ, q= -13.68kJ**

11. A piston/cylinder contains 2 kg water at 5 MPa, 800°C. The piston is loaded so pressure is proportional to volume, P = CV. It is now cooled by an external reservoir at 0°C to a final state of saturated vapor. Find the final pressure, work, heat transfer and the entropy generation for the process. (8.81) Ans: q12=-2376kJ, s_{gen}=5.52kJ/k w12=-292kJ

12. A cylinder/piston contains 100 L of air at 110 kPa, 25°C. The air is compressed in a reversible polytropic process to a final state of 800 kPa, 200°C. Assume the heat transfer is with the ambient at 25°C and determine the polytropic exponent *n* and the final volume of the air. Find the work done by the air, the heat transfer and the total entropy generation for the process. (8.69) Ans: q12= -5.155kJ, s_{gen}=.00366kJ/K